U.S. Environmental Protection Agency
National Estuary Program

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Information About Estuaries and Near Coastal Waters February 2003 - Issue 13.1

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South Slough NERR Team Investigates Estuarine Links to Pacific Ocean

In late September, dense fog forms along the southern Oregon coast when cold

upwelling ocean water meets warm air. At such times Coos Bay and its estuary are covered by a still gray blanket of fog. The fog is so thick that the NOAA Ship R/V MCARTHUR, a 175 foot-long research vessel, must cautiously slip out of Coos Bay between a narrow pair of rock jetties.

Aboard the ship is an interagency team of scientists from the South Slough National Estuarine Research Reserve (NERR), the University of Oregon Institute of Marine Biology (OIMB), Oregon State University (OSU), the National Marine Fisheries Service (NMFS) and NOAA Corps officers. The team is investigating physical and biological linkages between estuaries and the nearshore Pacific Ocean in the late fall of 2002.

Chief Scientist Dr. Steven Rumrill coordinates the research program at South Slough NERR. As he dons a hard hat and clips into a safety belt, he explains the need for integrated studies of the estuary and ocean. "Coos Bay and South Slough are separate arms of an estuary formed by the drowning of a river mouth. Ocean tides flood the estuary twice each day, and the tidal exchange and flushing are dramatic, especially during the summer when freshwater inputs from streams are low. In order to understand the ecological dynamics of the estuary, we need to also understand the behavior of continental shelf waters at our doorstep."

The team and ship's crew will collect water samples and biological and physical oceanographic data from 106 sampling stations. They will work round the clock for 9 days. The network of sampling stations begins 2 to 3 miles from shore and extends to a distance of 55 nautical miles offshore. Most sample stations will be visited twice during the cruise in order to characterize short-term dynamics over periods of 4 to 5 days.

At each station, the team members deploy a Conductivity-Temperature-Depth (CTD) cast, use Niskin bottles to collect water samples, and tow a pair of surface neuston and deep water zooplankton nets. Real-time digital data collected during the CTD casts allows researchers to develop vertical profiles of the water column on a computer screen. From these water column profiles, they can identify important hydrographic features such as thermoclines, pycnoclines, or haloclines that convey important information about the movement and structure of water masses.

Sea water from different depths is analyzed onboard for salinity, chlorophyll, fluorescence, dissolved oxygen, and a variety of nutrients including ammonium, nitrate, nitrite, and orthophosphate. Water chemistry provides information on the origin of water masses and their ability to support life. Zooplankton samples are preserved for later analysis in the laboratory, where they will be examined under the microscope to identify a variety of invertebrates including euphausiids, ctenophores, amphipods, decapod zoeae, megalopae, barnacle nauplii, cyprids, and smaller ciliated organisms that move in and out of the estuaries.

A few days into the cruise, dense fog reforms as cold upwelling again occurs. The ship is enveloped in fog that extends a distance of 8 to12 miles offshore. During the whiteout, scientists notice eelgrass (*Zostera marina*) adrift in the surface current about 4 miles offshore. Eelgrass is a flowering aquatic plant that forms broad meadows in tidal flats and shallow subtidal areas of South Slough and Coos Bay. The drifting eelgrass provides direct evidence that biological materials are transported from the estuary to the nearshore ocean.

Sixty miles from the mouth of the Coos Estuary, scientists, officers, and crew all pitch in to toss 1,300 drift bottles overboard. The bottles were prepared in advance by Marshfield High School students, under the direction of science teacher George Tinker, to learn about ocean currents. Each bottle is weighted to drift with surface currents and includes a return-address postcard. Drift bottles released in previous years (1995-2000) were carried by the California Current, across the Pacific Ocean, to the shores of Hawaii, Midway, Guam, and other islands in the Marianas and

Micronesia.

Such research along the Pacific Northwest coast reveals that the physical structure, circulation dynamics and biology of nearshore ocean waters are dictated by regional wind patterns that drive periodic upwelling and subsequent relaxation. During strong wind events leading to upwelling, surface waters move offshore, carrying shore-derived sediments, phytoplankton, and estuarine invertebrates out into the deep waters over the continental shelf. Conversely, during relaxation when the winds cease, offshore waters move shoreward, often carrying late-stage invertebrate larvae to coastal habitats and into estuaries. Periodic forcing by El Niño-Southern Oscillation (ENSO) events and longer-scale decadal regime changes also profoundly affect maritime climate and regional ocean conditions, as well as tidal circulation in the estuaries.

Oceanographic sampling can be difficult and dangerous, particularly in rough seas when work aboard a pitching vessel requires determination, sea legs, intestinal fortitude, and attention to safety. South Slough NERR scientist Michele Koehler does a balancing act as she returns to the ship's lab with an armload of water samples. Routine sampling in 28- knot winds and a huge swell pose serious challenges even to seasoned oceanographers!

But sample collection can also be daunting in the quiet waters of an urbanized estuary, where silence and fog bring the threat of collision with recreational boats, commercial fishing vessels, barges, and industrial freighters. In South Slough and Coos Bay, the scientists use small boats to collect measurements and conduct net tows. As usual, fog surrounds the boats in an eerie white silence as the crew quickly pulls in a net to retreat from the dangerous shipping lane. "A giant barge filled with dredged sediments just appeared out of nowhere," said South Slough NERR scientist Sue Powell as she processes a water sample from the channel. "We had to listen to the radio and keep a sharp eye out for larger boats that might suddenly emerge from the fog," adds Reserve scientist Tory Poulton.

Despite the difficulties of working at sea, the collaborative research is productive.

"We'll be better able to understand the ecology of this dynamic coastal zone, and particularly of commercially and recreationally important species of fish and shellfish," says Dr. Rumrill. These include Dungeness crabs (*Cancer magister*), burrowing shrimp (i), Pacific salmon (*Onchorhynchus spp.*), and larval and juvenile stages of Pacific Northwest groundfish (Sebastes spp.). The offshore oceanographic work being conducted at this NERR will help provide coastal resource agencies, fisheries biologists, and port managers with the factual information they need to make sound stewardship and management decisions closer to shore.

For further information, contact: Dr. Steven S. Rumrill, Research Coordinator, South Slough National Estuarine Research Reserve, Division of State Lands, P.O. Box 5471, Charleston, OR 97420; Phone: (541) 888-2581 ext 302; Email: Steve.Rumrill@state.or.us

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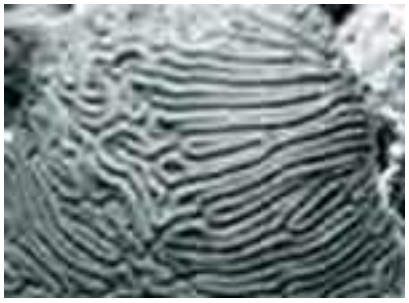
Marine Zoning in Florida Keys National Marine Sanctuary: Balancing Resource Protection and Uses

The Florida Keys National Marine Sanctuary (FKNMS) is a nearly 3,000 square-nautical-mile marine protected area that was designated in 1990 by Congress. The Sanctuary encompasses the marine waters surrounding the Florida Keys (see map), and includes mangrove islands, seagrass beds, hard-bottom communities, patch reefs, and offshore bank reefs. The purpose of the Sanctuary is to protect the

unique marine resources of the Florida Keys and to manage human use of these resources.



In its comprehensive management plan, the Sanctuary uses an important new resource protection tool: marine zoning, in combination with sanctuary regulations to protect marine resources. Five types of zones were implemented in July 1997, each with different objectives and regulations. Three of the zone types, (*Sanctuary Preservation Areas*, *Ecological Reserves*, and *Special Use / Research-only Areas*) include 24 fully protected "no-take" zones to protect critical habitat, preserve species diversity, and relieve human pressure on heavily used coral reef areas. In these zones, there are stringent restrictions on removing marine life and harming natural resources, to ensure their long-term conservation. The two remaining types of zones include 27 *Wildlife Management Areas* which protect shallow-water habitats, including seagrass flats, by restricting vessel operation and traffic.

Rationale

The Florida Keys have long been considered a unique national and international treasure. Deterioration of the marine environment in the Keys is a matter of record. Florida Bay has experienced ecological degradation since the late 1980s in terms of productivity, health, and stability of the Bay's living marine resources. Water quality in the Florida Keys has deteriorated due to local sources such as inadequately treated wastewater and stormwater, and regional sources such as runoff from the mainland and nutrient-rich seawater from the Gulf of Mexico. The quantity of water entering south Florida coastal waters from the Everglades has also been profoundly reduced by decades of filling and draining of the Everglades. As a result, health of coral reefs has declined, as indicated by increases in coral diseases, increased extent and severity of coral bleaching, and decreases in the area of living coral reefs. Corals are also damaged by numerous small-boat groundings, occasional large ship groundings, and snorkelers and divers who break off corals. Fisheries scientists are reporting declines in fish stocks, which affect commercial and recreational fisheries and ecosystem structure and function.

The economy and the environment of the Keys are inextricably linked. Each year, over 3 million visitors spend 13 million visitor-days in the Keys and spend $1.2 billion snorkeling, diving, fishing, boating and enjoying the tropical coastal environment. If the marine environment of the Keys continues to decline, so will the economy of the Keys and south Florida. All of these factors led Congress to designate the FKNMS in 1990.

Goals of the Fully Protected Zones

Marine zoning is critical to achieving the Sanctuary's primary goal of resource protection. Marine zoning is designed to protect and preserve sensitive components of the ecosystem by regulating human uses within zoned areas, while allowing activities that are compatible with resource protection. Ecologically important areas can be protected so that they remain in a more natural state, with reduced human influence. Marine zoning also promotes sustainable use of Sanctuary resources, protects diverse habitats, and preserves important natural resources and ecosystem functions.

Ecological Reserves, or "no-take" marine reserves, encompass large areas of contiguous and diverse habitats. They are designed to preserve biodiversity; provide spawning, nursery, and residence areas for marine life; protect habitats and species not addressed by existing fishery management regulations; and allow areas to remain in or return to a more natural state. *Sanctuary Preservation Areas* are smaller zones situated along heavily used areas of the reef system. These zones separate conflicting uses and prevent further resource degradation. *Special Use / Research-only Areas* are areas set aside for scientific research and educational purposes. Entry into these areas is restricted, allowing scientists to monitor the ecological effects of no diving and no-take regulations.

Selecting Areas for Marine Reserves

During the 1990-1996 Sanctuary planning process, marine zoning was the most controversial management tool being considered. The most debated topics in establishing marine zoning were proposed locations, allowable uses, and sizes.

The most controversial marine zone types included the areas under consideration for "no-take" protection. In 1992, NOAA proposed a marine zoning plan that set aside 12% of the Sanctuary as "no take" areas. Following months of discussion, study, and field visits, the area was reduced to 6% in the Draft Management Plan released in 1995. The outcry against the size of the "no take" areas was so loud that the 1996 Final Management Plan had a marine zoning plan with only 1% of the Sanctuary in fully protected zones. The plan was left with only the smallest ecological reserve (nine square nautical miles); however, there was a commitment to establish an ecological reserve in the Tortugas region of the Sanctuary.

In 2001, the Tortugas Ecological Reserve (151 square nautical miles) was established to better meet the Sanctuary's goals of resource protection. This new reserve preserves species richness in one of the finest coral reef environments in the Sanctuary. The Tortugas region also serves as a source of larvae throughout

the Florida Keys. Preserving such a "larval stock area" will help to ensure the stability of commercial and recreational fisheries and ecosystem health. Scientists hope that the reserve's geographical isolation will help them to distinguish between natural and human-caused changes to the coral reef environment. Today, approximately 6% of the Sanctuary (10% of the coral reef habitat in the Keys) is in fully protected zones.

Preliminary Ecological Effects of the Fully Protected Zones

In the five years since marine zoning was adopted, monitoring studies indicate that some heavily exploited species have increased in abundance and size in the Sanctuary's no-take areas, when compared to nearby less-protected reference sites. For example, legal-sized spiny lobsters are more abundant in fully protected zones than in less-protected reference sites with comparable habitat. The average size of lobsters within the Western Sambo Ecological Reserve is now significantly larger than in less-protected reference areas. Catch rates (number of lobsters per trap) in a Sentinel Fishery Project are also higher in the Ecological Reserve than in two adjacent fished areas, further signifying that the population has increased in protected area.

In no-take zones, some reef fish species have increased in abundance over time, some as much as 30-fold after five years. Ongoing research is aimed at determining whether the health of coral reef ecosystems can be fully restored. Together with appropriate regulations, marine zoning promises to be a highly effective new tool for coastal managers seeking to balance resource protection with human uses.

For further information, contact Dr. Brian D. Keller, Science Coordinator, Florida Keys National Marine Sanctuary; P.O. Box 500368, Marathon, FL 33050; Phone: (305) 743-2437 ext. 25; Fax: (305) 743-2357; Email: brian.keller@noaa.gov; or Billy D. Causey, Superintendent, Florida Keys National Marine Sanctuary; Phone: (305) 743-2437 ext. 26 www.fknms.nos.noaa.gov

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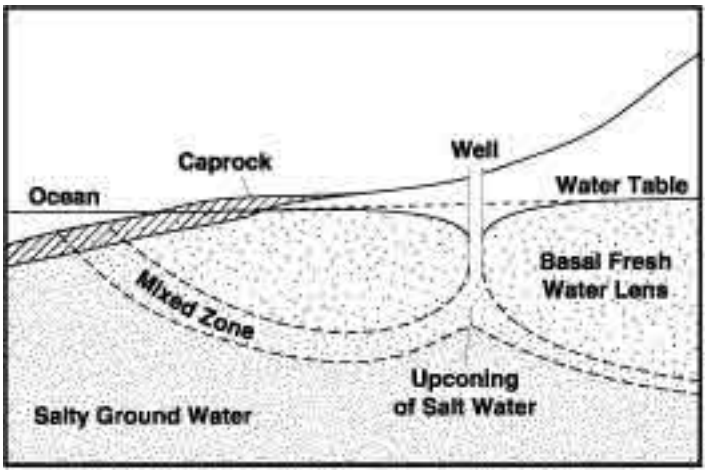
Geological Survey of Alabama Monitors Saltwater Encroachment for Mobile Bay NEP



Saltwater encroachment into fresh groundwater is a serious concern for many coastal communities that rely upon groundwater aquifers for drinking water. As drinking water aquifers become depleted due to well pumping, seawater can flow into the subsurface, replacing fresh groundwater with salt water. Fresh water wetlands that rely upon a high water table may also be damaged by rising salt levels due to saltwater encroachment (also known as saltwater intrusion).

In order to better understand the balance between fresh and salt water in South Alabama coastal areas, the Mobile Bay National Estuary Program (MBNEP) purchased three groundwater sensors to monitor salt concentrations (using

measurements of specific conductance) in the freshwater aquifers in the area of Gulf Shores, Alabama. These sensors were provided to the Geological Survey of Alabama (GSA), who will be conducting the groundwater monitoring.

"We (the GSA) conducted a saltwater encroachment study in 1984-85 and found salt water in shallow aquifers at a few places in Gulf Shores," reported Danny Moore who is the Director of the Hydrogeology Division at GSA. "Since then, we have been interested in continuously monitoring for saltwater encroachment, particularly since all of Baldwin County relies solely on ground water for public water supplies and because ground water development has increased greatly since then."

In its Comprehensive Conservation and Management Plan (CCMP), the Mobile Bay NEP specifically addresses groundwater quality as a priority issue. The management action requires working with state and local agencies like the Geological Survey of Alabama to maintain groundwater quality.

Baldwin County is the fastest growing county in Alabama. Much development has occurred in the coastal resort communities of Foley, Gulf Shores, Orange Beach, and the Bon Secour Peninsula. In these areas, population growth and development and demands for water pose challenges for maintaining and protecting drinking water aquifers. Saltwater encroachment has been a concern for resort communities in many areas along the Gulf Coast. Rapid population growth accompanied by increased demand for limited drinking water supplies has resulted in declining groundwater levels and potential saltwater encroachment. Fresh water is a valuable commodity that may rise in cost as demand increases and supply diminishes. Often towns find themselves purchasing water from other areas as their own groundwater is diminished in quantity and quality from over-pumping and high demand.

Neighboring communities along the Gulf Coast, such as Okaloosa County, Florida, are already projecting their water needs decades into the future, and are looking for alternative sources of drinking water. Many urban communities pump more water than the aquifer can recharge. In coastal communities such as Gulf Shores, Alabama, groundwater is already limited by the aquifer's proximity to Gulf waters.

When it rains, water infiltrates into the ground as well as flowing along the surface of the ground. Infiltrated water percolates downward until it reaches the water table. If water is withdrawn from a well, the water table is lowered in the immediate vicinity of the well. As the pumping continues, groundwater levels within the aquifer may be lowered even more. If pumping stops, the levels will rise or recover. Groundwater levels also respond to seasonal cycles of rainfall and drought.

Saltwater encroachment can occur within an aquifer in several ways. Some aquifers

are layered, with fresh water lying on top and denser saltwater lying at the bottom of the aquifer. As the fresh water is withdrawn by pumping, saltwater is encountered. On islands and in coastal communities, a sensitive balance exists at the interface between fresh groundwater and marine seawater. This interface is not fixed, but moves according to the relative amounts of fresh water vs. salt water. As fresh water is withdrawn, the saltwater-fresh water interface moves further inland, as saltwater moves into subsurface areas which once contained fresh water.

The probes installed in the monitoring wells measure the specific conductance of the water. The higher the salt content is, the higher the specific conductance is. A measurement is made and recorded every 2 hours and the data are retrieved from the wells every six weeks. The GSA also monitors the water level in these 3 wells. The monitoring wells range in depth from 130 to 315 feet. The new GSA monitors (specific conductance probes) were installed in September 2002. This information will be useful for local decision makers to wisely manage the resource as the area continues to grow. The data will also be available to the public and to educators.

Alabama is rich in water resources, but these resources face risks such as saltwater encroachment and depletion due to demand. Agencies are beginning to educate the public on how to protect and conserve this valuable commodity. The Mobile Bay NEP and other local organizations are organizing workshops and presentations to educate the public on hydrology, groundwater contamination, groundwater recharge and municipal programs. Other information is also being developed for local officials on hydrology, water conservation, alternative uses for gray water, and landscaping alternatives that use less water. Purchasing the saltwater sensors may seem like a small action item, but the monitoring information will prove invaluable to coastal Alabama communities.

For further information, contact Lee Yokel, Outreach Coordinator, Mobile Bay National Estuary Program, 4172 Commanders Drive, Mobile, AL 36615; Phone: (251) 431-6409; Fax: (251) 431-6450; Email: lyokel@mobilebaynep.com; website: www.mobilebaynep.com EXIT disclaimer; or Geological Survey of Alabama, 420 Hackberry Lane, Tuscaloosa, AL 35486; Phone: (205) 349-2852; website: www.gsa.state.al.us EXIT disclaimer.

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PEW Oceans Commission Report

For the first time in 30 years, America's oceans and coasts are getting a thorough review by a blue-ribbon panel of experts. The Pew Oceans Commission Report was compiled by a bipartisan group of top-ranking scientists, elected officials, fishermen, and business and environmental leaders. To learn about the state of America's oceans and coasts, the Commission traveled from Maine to Hawaii, and from the Gulf of Alaska to the Gulf of Mexico, collecting information from people from all walks of life. The Commission has documented unprecedented problems facing the marine environment: dead zones, collapsing fisheries, toxic contamination of ocean resources, exploding coastal development, and a lack of clear national leadership. Next month, the Commission will release a comprehensive report that documents the threats to the seas, and recommends actions that must be taken to restore and conserve ocean life.

For further information on the Pew Oceans Commission or to view the report when published, visit their website at www.pewsocean.org EXIT disclaimer.

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Release of the National Environmental Methods Index

On the 30th Anniversary of the Clean Water Act, the Environmental Protection Agency and U.S. Geological Survey are pleased to announce the public release of the National Environmental Methods Index (NEMI). NEMI is a free, standardized web-searchable database of environmental monitoring methods that allows monitoring data to be shared among agencies and organizations that use different methods at different times. This will allow scientists and managers to compare data collection and search for more appropriate monitoring techniques. The NEMI database contains method summaries of laboratory and field protocols used for regulatory and non-regulatory related water-quality analyses.

For further information visit the National Environmental Methods Index at www.nemi.gov. EXIT disclaimer.

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Volunteers Monitor Stormwater and Help Develop TMDLs in Santa Monica Bay

In 2001, visitors to California's coast spent over $61 billion and generated over $15 billion in tax revenue. Yet, despite the obvious importance of coastal resources, beaches along Santa Monica Bay near Los Angeles still have warning signs and beach closures due to pollution. Indeed, swimming in runoff-polluted waters quadruples one's chance of getting sick, according to a 1996 study of Santa Monica Bay conducted by the University of Southern California.

Fortunately, residents have begun to realize that the main cause of this pollution is not so far removed: it actually comes from urban stormwater runoff from local neighborhoods. Many individuals have decided to address the problem by participating in Santa Monica Baykeeper's Beachkeeper Water Quality Monitoring Program.

The Beachkeeper program is a volunteer monitoring program that involves the local community in identifying sources of urban stormwater runoff. By becoming Beachkeeper volunteers, members of the local community are showing their concern for the environment and are taking an active role in protecting their coastal resources.

From its inception in 1996, the Beachkeeper program has provided water quality data and source identification for polluted stormwater that flows into Santa Monica Bay. This information is disseminated to the community, municipalities, and government agencies such as the Los Angeles Regional Water Quality Control

Board (Regional Water Board), which uses the results to devise plans to reduce - and ultimately stop - pollution from reaching local waters. With the assistance of many, the Beachkeeper Monitoring Program has evolved into a credible source of high quality data and information for local and state water quality agencies.

In the past three years alone, Beachkeeper volunteers have made over 2,000 drain observations - including collecting more than 1,000 stormwater samples - and have found that stormwater from the majority of flowing drains along the Bay regularly exceed bacterial water quality standards set by the state. The Beachkeeper program has identified over 350 storm drains and discharges emptying into Santa Monica Bay, extending from Point Dume in Malibu to Malaga Cove in Palos Verdes. Stormwater samples collected over the past few years were analyzed for different pollutants, including bacteria and heavy metals, in order to identify the most polluting storm drains in Santa Monica Bay. Beachkeeper volunteers have also developed a catalog of storm drains - which includes GPS coordinates and photographs of every storm drain that empties into the Bay.

The Beachkeeper program will also provide information needed to implement and develop Total Maximum Daily Loads (TMDLs) for Santa Monica Bay. A TMDL specifies a daily limit on pollutant loadings, based on pollutant loadings from all sources in the entire watershed. A TMDL also allocates responsibility for pollution to each contributing source, hence the importance of identifying sources of pollution. The federal Clean Water Act requires states to develop and implement TMDLs in order to control nonpoint source pollution of watersheds. Separate TMDLs can be developed for separate pollutants, such as nutrients, fecal coliform bacteria, and other pollutants.

The Beachkeeper monitoring program fully complements the TMDL program. The Regional Water Board uses such monitoring information to help identify potential pollutant sources to meet the regulatory requirements of the dry weather bacteria

TMDL adopted in 2002. This TMDL prohibits all exceedances of state health standards for bacteria in the summertime within three years, and within six years will limit exceedances during winter dry weather to a level that would be observed only under natural conditions (e.g., as if no humans were present). The TMDL also requires cities to identify ownership of these drains and to file reports on the nature of their discharge.

Volunteer water quality monitoring data also serves as baseline data and will be used in developing upcoming TMDLs for other pollutants, such as TMDLs for wet weather runoff. In Southern California, wet weather may be necessary for ending drought conditions, but winter rains also cause billions of gallons of untreated urban stormwater runoff to enter the Bay from hundreds of storm drains and urbanized creeks. Sampling of such "first flush" effluent directly from storm drains gives accurate information concerning the types and concentrations of pollutants that accumulate on our local streets. Because of the importance of wet weather sampling, Beachkeeper volunteers have collected water samples from three "first flush" rain events from the past three winter seasons.

Results of stormwater testing in the first five years of sampling will provide a strong foundation for ongoing efforts to clean up Santa Monica Bay and its watersheds. One major accomplishment is the heightened interest in water quality expressed by government agencies as well as community members. This interest, combined with the hard work and dedication shown by the volunteers involved with this program, has elevated volunteer monitoring to an entirely new level in Los Angeles. Working together, state water quality officials, local environmental groups and citizens are proving that partnerships and teamwork can solve coastal water quality problems.

For further information contact, Angie Bera, BeachKeeper Program Director/Staff Biologist, Santa Monica Baykeeper, P.O. Box 10096, Marina del Rey, CA 90295; Phone: (310) 305-9645 ext.3; Fax: (310) 305-7985; Email: octopus@smbaykeeper.org

DuluthStreams: Partnerships For Understanding Water Quality and Stormwater Impacts at the Head of the Great Lakes

Duluth, Minnesota, lies at the western end of Lake Superior, at the headwaters of the Laurentian Great Lakes ecosystem. With 42 streams, including 12 designated coldwater trout streams, Duluth has one of the highest stream densities of any US metropolitan area. Since the topography slopes steeply, the streams transport much

stormwater and snowmelt runoff into Lake Superior and the St. Louis River Estuary/Duluth-Superior Harbor, classified as a Great Lakes Area of Concern.

Duluth's stormwater infrastructure combines 93 miles of streams and wetlands with more than 138 miles of roadway ditches and culverts and 250 miles of underground storm drains. Stormwater runoff from urban areas and rural development typically impact streams and wetlands by increasing metal and organic pollutants, temperature, turbidity, suspended sediments, road salt, organic matter, nutrients, and possibly disease-causing microorganisms.

In January 2002, a partnership between City of Duluth, the University of Minnesota, local resource agencies, and schools was formed to increase public understanding of streams and the impacts of watershed land use and stormwater runoff. This partnership, called DuluthStreams, was made possible by funding from EPA's EMPACT program (Environmental Monitoring for Public Access and Community Tracking; http://www.epa.gov/empact). Forming a partnership under EMPACT does not require creation of a separate organization, but instead is based on partners signing a memorandum of understanding. Partners can include government agencies, citizens groups, educational institutions, and non-profit organizations. A lead government agency must be designated, to ensure that the partnership will endure following the initial federal grant.

The City of Duluth is the lead agency for DuluthStreams. The partnership includes researchers and educators from the University of Minnesota-Duluth's Natural Resources Research Institute and Minnesota Sea Grant, City of Duluth stormwater utility staff, the Minnesota Pollution Control Agency, the Western Lake Superior Sanitary District, the Great Lakes Aquarium, and the Lake Superior (Duluth) Zoo. University of Minnesota, City and agency staff monitor stream water quality and provide the information to local resource managers and the public via a new website. The University is developing the website and data visualization tools, and assisting the City with educational curricula. The project is coordinated with Duluth's Stormwater Management Plan and will help the City comply with EPA's Phase II Storm Water Rules.

DuluthStreams has the following goals:

1)To link real-time remotely sensed water quality data from four urban streams and water quality and biological databases for all 42 Duluth streams, using data visualization tools and GIS maps in Internet and Information Kiosk formats;

2) To develop interesting graphics, interpretive text, animations and videos to illustrate the nature and consequences of stormwater runoff and the real costs to society, and distribute these via the DuluthStreams website (www.duluthstreams.org) and kiosks at the Great Lakes Aquarium and Duluth Zoo; and

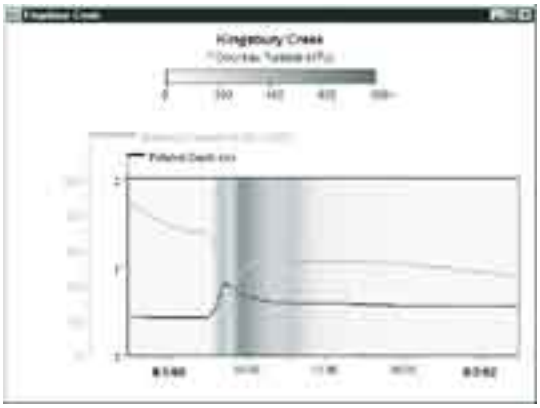
3) To involve the public in improving stormwater management through a number of programs. Programs include neighborhood stewardship and monitoring of streams by schools, developing curricula, and hosting a Duluth Streams Congress as a community forum for presenting project results. Providing training of municipal officials is planned through tailoring of the NEMO (Nonpoint Education for Municipal Officials) program to the Duluth Area.

DuluthStreams will use sensors to monitor streams for water flow, temperature, conductivity, and turbidity, and transmit the information to the website. Researchers will regularly collect water samples for a variety of water quality analyses. The website will be a repository for maps, reports, community activities and other information on water resources that is currently scattered and difficult to access. Local scientists will interpret the data so that it can be understood and used by resource managers, teachers, students, developers, and the public at large.

DuluthStreams embodies the principle of the EMPACT program: that a well-informed public will make better decisions about land use. As citizens become more aware of streams and the causes of pollution, they will be encouraged to protect and improve their streams by identifying harmful practices, implementing Best Management Practices (BMPs), and monitoring local streams.

DuluthStreams is the third spin-off since 1997 from the successful Water-on-the-Web (WOW) science curriculum funded by the National Science Foundation (NSF). WOW uses lake data to educate high school and college students about basic science and aquatic ecology. WOW deployed a new sampling device called RUSS (Remote Underwater Sampling Station, developed by Apprise Technologies) in a number of Minnesota lakes to collect depth profiles of temperature, oxygen, pH, conductivity and turbidity and more recently, chlorophyll fluorescence. Data are posted daily on the WOW website (wow.nrri.umn.edu) and animated with graphics that can be used in basic science and ecology curricula. WOW is currently being

adapted to provide a year-long training curriculum for water science technicians using time-series data from aquatic ecosystems nationwide and from Minnesota lakes and streams.



Similar approaches are being used for LakeAccess, which is also funded by EPA's EMPACT program. LakeAccess focuses on Minneapolis water bodies 160 miles to the south of the area served by the DuluthStreams project. LakeAccess uses a website (www.lakeaccess.org) and information kiosks to post data from time-series lake and stream sampling in Lake Minnetonka and nearby Minneapolis metro area lakes, other water quality and biological data, and watershed-based land use and demographic data.

LakeAccess not only provides public access to the data, but also provides interpretation of the data, to assist community decision-making. For example, in 2001, the lead agency for LakeAccess, the Hennepin Parks-Three Rivers Park District, began stormwater monitoring to evaluate the effects of lawn fertilizers on a eutrophic lake in the Minneapolis metropolitan area. They deployed automated stormwater sampling systems in watersheds with and without phosphorus fertilizer restrictions, and in tributary streams to evaluate this source of phosphorus loading to the nutrient budget of eutrophic Medicine Lake.

In all of these programs, real data, such as time-series data, are incorporated into educational curricula and outreach materials to inform the public and improve environmental decision-making. The combination of DuluthStreams, WOW and LakeAccess provides a cost-effective approach to public outreach, since educational programs can be coordinated and distributed over a larger geographic area and to more people. DuluthStreams shows how tools developed for the Minneapolis urban area have been tailored for a northern Minnesota community that is now facing significant development and storm water management issues.

For further information, contact Marnie Lonsdale, City of Duluth Stormwater Utility Operations, 600 Garfield Ave, Duluth, MN 55802; Phone: 218-723-3551; Email:

mlonsdale@ci.duluth.mn.us or Rich Axler, Natural Resources Research Institute, University of Minnesota-Duluth, 5013 Miller Trunk Highway, Duluth, MN 55811; Phone: 218-720-4316; Email: raxler@nrri.umn.edu

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Lunching on Loosestrife

Although purple loosestrife may not be on everyone's lunch menu, it is a staple food item for black-margined loosestrife beetles, or *Galerucella calmariensis*. These foreign beetles keep their invasive cuisine from dominating the plant community in many wetlands throughout North America.

"I can't believe the difference," said Shari McCorison, 4-H Program associate for the University of Minnesota Extension Service. Fingering a tattered purple loosestrife plant, peppered with holes and browning leaves, she called out to the group of volunteers, "Just look at this! I think it's safe to say that this bio-control project is a success!"

Small beetles with large appetites for purple loosestrife did what the 4-H volunteers, parents, and sponsoring staff hoped they would - they ate their way through acres of the invasive plant. Impressively, the leaf-chewing bud-eating beetles completed this Herculean task in two years. Now native vegetation once again dominates the treated wetlands.

Purple Power

Purple loosestrife (*Lythrum salicaria*) looks beautiful and is still popular with beekeepers and bees, but it originated from Europe and Asia and is not native to North America. About 200 years ago, people introduced this now-troublesome but attractive perennial to North America. It spread rapidly throughout the continental United States and Canada, outgrowing and replacing native wetland vegetation.

Once it has spread throughout an area, eradicating purple loosestrife is nearly impossible. Current control efforts are shifting away from herbicide treatments and focusing on biological control using several host-specific insect species. Hundreds of programs across North America are reducing purple loosestrife's ability to dominate an ecosystem by releasing insects in infested wetlands and providing public outreach to help minimize the spread of the invasive plants.

Inter-species Partnership

Minnesota Sea Grant has undertaken a successful partnership with the beetles, the Minnesota Department of Natural Resources (DNR), the St. Louis River Citizens Action Committee, 4-H and several other youth organizations to tackle purple loosestrife infestations. This unusual partnership began in 2000. *Galerucella* beetles were hand-picked from a DNR bio-control project in northwestern Minnesota and were then whisked to Duluth, Minnesota. Upon arrival, the nondescript beetles were adopted by volunteer beetle farmers. The offspring of these breeder beetles were released into purple loosestrife-infested areas of the St. Louis River near Duluth.

The following year, 4-H volunteers and staff donned sunscreen and mud boots to gather several thousand descendants of the now-dead first generation of beetles. They pampered these youngsters in their backyards. Protected from predators and some of the harsher aspects of living wild, the second generation matured and created a whole new generation of loosestrife-hungry beetles that were released in other infested wetlands along the St. Louis River.

The biological control project was so successful that this past year, volunteers, after dutifully digging up and potting purple loosestrife rootstocks to grow as beetle fodder in kiddy pools, found that a surprising proportion of beetle stocks were dead. This reduction in the number of backyard beetle nurseries, coupled with an

unusually cold spring, made beetle rearing more challenging but no less important.

"The beetles have done a splendid job," said McCorison, "but they're not done yet and neither are we." The beetles are good at their jobs but they don't travel outside of the area in which they are released. Although the odd few might fly several kilometers for fresh pickings, most are sedentary. This year, 55 volunteers raised roughly 100,000 black-margined loosestrife beetles and released them in other areas of the St. Louis River that are predominantly purple.

"We're extremely pleased with the difference Galerucella have made in the plant diversity," said Doug Jensen, the coordinator of Minnesota Sea Grant's Exotic Species Information Center. "Instead of wetlands choked with loosestrife, I'd estimate that native species are growing over about 85 percent of the treated areas."

Meet the Purple Plant Eater

A black-margined loosestrife beetle is about the size and color of a lentil, and is drab and unimpressive. However, the beetle shines in its specialty - eating purple loosestrife. After years of careful study and quarantine, beetles obtained from northern Germany gained U. S. Department of Agriculture approval for release in North America as a purple loosestrife control agent in 1992.

Now the beetles are helping to reduce purple loosestrife infestations in over 30 states and 6 provinces. In Minnesota alone, over five million of these beetles have been released in infested wetlands. Many reports suggest that larval and adult beetles have managed to defoliate about 80 percent of some loosestrife populations.

Galerucella's gift for eating purple loosestrife co-evolved with the plant itself in Europe and Asia. There are several insects that have been brought to North America to tackle purple loosestrife. Galerucella specialize in eating shoots, buds, and other above-ground parts of purple loosestrife plants.

Galerucella live short lives dedicated to eating and reproducing. In spring, hibernating adults emerge at about the same time that purple loosestrife roots begin to send up new shoots. After mating, females typically lay about 300 eggs over a period of 30 days. Eggs hatch into ravenous yellowish larvae in about 20 days; in another 20 days the larvae pupate for two to three weeks and emerge as hungry adults.

Galerucella attacks dinner in two ways. Larvae strip the photosynthetic tissue from

plants and at high densities (more than 2 larvae per centimeter of shoot) they can defoliate entire purple loosestrife plants. Adults eat leaves, shoots, and buds. The resulting leaf damage greatly reduces a plant's photosynthetic capability, thereby reducing starch storage in the roots and increasing winter plant mortality. Less severe attacks can reduce shoot growth, inhibit flowering, eliminate seed production, and impede root growth. Attacks also increase the branching pattern of purple loosestrife; attacked plants are shorter and appear "bushier" than unattacked individuals.

For more information about purple loosestrife, black-margined loosestrife beetles, or other bio-control efforts, search the Internet. Michigan Sea Grant's Purple Pages (www.miseagrant.org/pp EXIT disclaimer) contains a list of North American contacts for controlling purple loosestrife. You can also contact your state's natural resource agency or Sea Grant Program for additional information.

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Note: This information is provided for reference purposes only. Although the information provided here was accurate and current when first created, it is now outdated.

Predators Provide Top-Down Control of Salt Marsh Productivity

Salt marshes are among the most productive ecosystems in the world and play a critical role in the ecology and economy of coastal areas. Salt marshes reduce erosion, temper coastal flooding, filter terrestrial run-off, act as sinks for nutrients and greenhouse gases, and provide nursery and feeding habitat for commercially important fish and shellfish species (blue crabs, shrimp, oysters, red drum, spot, croaker, sea trout). The health and long-term future of many fisheries ultimately depend on the health of salt marshes, which form the basis for many coastal food webs. Understanding the factors that affect salt marsh productivity is important for

managing and using coastal resources.

Salt marshes have long been viewed by ecologists as the model example of an ecosystem controlled by "bottom-up factors", e.g.nutrients and physical factors. Most research into salt marsh productivity has focused on the role of physicochemical factors such as salinity, oxygen, nutrients, tidal flushing, and freshwater input, that regulate growth of salt marsh species. Such research indicates that salt marsh health is largely affected by: 1) Point and non-point source pollution (metal and organic contaminants and nutrients), 2) Freshwater divergence (which increases salinity), 3) Erosion due to sea level rise, storms, and aquifer depletion, and 4) Dredging and reclamation projects which result in draining, filling or channelization of wetlands.

Recently, studies of salt marshes in Georgia and Virginia indicate that predatory-prey relationships, in addition to nutrient limitation, are also important in controlling salt marsh productivity,. These studies used caging experiments to vary densities of snails (marsh periwinkle) and their predators (such as blue crabs, terrapins, mud crabs, and killifish). The results suggest that predators indirectly promote salt marsh biomass and productivity by preying on plant-grazing snails, a top-down process called trophic cascade. In the absence of predators, snail populations can increase to a point where they can convert salt marsh into barren mudflats in 8 months.

Marsh periwinkles (*Littoraria irrorata*) are one of the most common and widespread grazers in southeastern marshes and can be extremely abundant, reaching densities of ~50-800 individuals / m2. They were long thought to be detritivores, but cagingn experiments showed that at moderate densities, *Littoraria* switches from feeding on organic detritus to live *Spartina*. In addition, the strength of this interaction increased as nitrogen fertilizers were added to the salt marsh. Although periwinkles do not actually consume large amounts of live plant tissue (they instead "farm" fungi on grazer-induced wounds on green leaves), surface wounds left by grazing cause drastic reductions in marsh productivity and, at times, near-destruction of the marsh canopy.

Combined, these experimental results challenge the "bottom-up" paradigm of marsh ecology and indicate that trophic cascades strongly influence the structure and function of southeastern salt marshes. Thus, both bottom-up and top-down processes may together determine salt marsh persistence.

Why were such top-down forces overlooked for so long? Early studies in salt marsh ecology assumed that dying marsh vegetation and detritus attracted invertebrate grazers (detritivores). They did not test the alternative hypothesis that invertebrate grazers helped to create organic detritus through intensive grazing, or that

predators promoted salt marsh growth by keeping grazers in check. These results highlight the importance of manipulative experimentation in investigating how communities are organized.

The implications for coastal conservation and management are that over-exploitation of predators such as blue crabs and terrapins could lead to the collapse of southeastern salt marshes by removing predators which keep grazing populations under control.

However, more work is needed to investigate the importance of marine predators (e.g., blue crabs, fish, terrapins) in regulating periwinkle populations. More research is also needed to understand whether or not marine predators that are left will compensate for the loss of harvested predators by increasing predation on plant-grazing snails.

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Beware the Bighead Carp Invasion!

Coastal areas throughout the country have experienced environmental and economic hardships due to invasive species such as zebra mussels, the Asian shore crab, Phragmites, and many other unwelcome invaders. Now the bighead carp, an invasive species from Asia, is poised to invade the Great Lakes region.

A massive project is under way to stop the carp migration. The Environmental Protection Agency (EPA) announced the allocation of $150,000 in emergency funds, the Army Corps of Engineers contributed in-kind services amounting to $50,000 and the U.S. Department of State, working through the Great Lakes Fishery Commission and International Joint Commission, designated funds to help prevent the bighead carp from entering the Great Lakes. The resources will be used to purchase and install backup power for an electrical barrier already in place at the Chicago Sanitary and Ship Canal near Romeoville, Illinois, to defend against the migration of carp into the Great Lakes region.

The problem is urgent, since bighead carp have been found within 50 miles of Lake Michigan. Field testing of the barrier has already begun and preliminary reports on the response of carp to a simulated electrical barrier (in a fish hatchery), showed that 99 percent of invasive fish were repelled.

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